Nuclear data Exercises

1. What is the total energy released (Q-value) in the spontaneous transformation of Po-210 to Pb-206 by alpha emission?

2. What is the a) average, and b) maximum alpha particle energy for the spontaneous transformation of Pu-239?

3. What is the maximum kinetic energy of the betas released in the spontaneous transformation of Sr-89 to Y-89?

4. What is the average beta kinetic energy? Note that the average kinetic energy is approximately 1/3 of the maximum value.

5. 4. The decay of Fe-55 by electron capture to Mn-55 can be written Fe-55 → Mn-55* + ν in which an inner shell electron in Fe-55 is captured by the nucleus and combines with a proton (i.e. e + p → n + ν) in the nucleus to form a neutron and a neutrino ν. The process of electron capture leaves a vacancy in an electron shell that is then filled immediately by electrons form higher levels cascading down. The process is characterised by the emission of xrays and associated Auger electrons.
   a). What is the total decay energy (Q-value) for this reaction?
   b) What is the energy of the mono-energetic neutrino created in this reaction?
   c). What percentage of the total decay energy is carried away by the neutrino?
   d). What is the isotopic (heat) power of Fe-55?
   e). What is the total power (per gram) emitted?

6. Nuclear reactor power is driven by the nuclear fission of U-235 with thermal neutrons (E= 0.025 keV = 2.2km/s).
   a. How much is fission predominant compared to neutron capture – (n,γ) reaction- and scattering?
   b. Find the two main fission products from the thermal fission of U-235 with half-lives within 25-35 years.
   c. Assuming an average 3 neutrons emission by fission determine for the two fission products found in 6.b. the other fission products produced during the binary fission.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow \left(^{236}_{92}U\right)^{*} \rightarrow ^{A}_{z}X + ^{236-A-3}_{92-z}Y + 3\cdot ^{1}_{0}n$$

   d. What's the amount of the 4 fission products produced per 1 tone of U-235?

e. What's the decays heat produced by the two fission products found in 6.b.?

f. What amounts of U-235 shall be fissioned in order to produce the annual limits of toxicity (inhalation and ingestion) for the two fission products found in 6.b.?

7. The fast neutron activation was found to be an efficient, quick and accurate method of characterizing the precious metal objects routinely in bulk, with a large sample throughput. In this exercise the researcher is interested to analyze gold jewelry using neutron activation.
   a. Describe the reaction (parent/daughters of the reaction)
   b. Looking at the cross-section, which neutron spectrum is more favorable for the activation?
   c. The researcher is interested in prompt gamma emission. Which lines will he measure?
   d. If he were doing delayed gamma spectroscopy, which lines would he measure?
   e. The researcher is actually irradiating a 2 g gold sample (18 carats i.e. 75% gold content) with a 14 MeV neutron flux of 4.10^7 $n.cm^{-2}.s^{-1}$ during 1 min. How much activated gold (atoms and grams) did he produced at the end of the irradiation? What does that activated gold becomes after 27 days?